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GASIFICATION OF AGRICULTURAL RESIDUES

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Large amounts of available agricultural residues in many cases are either going to waste or being utilized inefficiently. Since gasification of any carbonaceous material produces a combustible gas, it was considered of interest to explore the possibility of gas produced from such a source, e.g., corncobs, as a suitable fuel for internal combustion engines.

In a previous publication from this Laboratory on the thermodynamics of producer gas combustion (3)[1], reference was made to this work in connection with two gas compositions used in the calculations. It was pointed out that the heat of combustion of a cubic foot of a theoretical mixture of producer gas and air is only about 60 percent of that of a similar mixture containing gasoline. Various steps were suggested to overcome this deficiency. Results of past work are available in an annotated bibliography on construction, design, economics, performance, and theory of portable and small stationary gas producers, which contains more than 500 references (2).

More recently, Lustig (1) has published experimental data obtained at the plant of the Wellman Engineering Company with a large gas producer which uses agricultural residues, such as cottonseed hulls and others. The gas, tested in a 4-cycle Bruce-MacBeth gas engine, gave satisfactory results.

Apparatus and Operation

Figure 1 is a diagrammatic sketch of one of the experimental gas producers used in this work. Another model, more elaborately constructed, performed practically as well. The apparatus (figure 1) was designed for easy accessibility and flexibility and to reproduce approximately the average conditions of operation of a down-draft, vehicle gas producer. This type is better suited for fuels that contain appreciable amounts of volatile matter, such as agricultural residues and wood, than for those that operate on either the cross- or up-draft principle, since any incompletely burned particles of tar must pass through the glowing charcoal and ash bed above the grate where they will be volatilized.

The distance of the tuyère above the fire zone and also the air flow will effect composition of the gas. Results in table 1 indicate an optimum distance of about 16 1/2 inches below the cover of the hopper for the particular generator.

Fuel size was found to be important, and a gas of higher heat content is obtainable from coarsely ground corncobs (table 2) than from whole cobs (see table 1). This might be attributed to the larger reaction surface exposed and to closer packing with consequent higher temperature. Since the quality of the gas dropped toward the end of the run, it was good practice to refill the hopper after only about three-fourths of the charge had been consumed. This procedure was used in the three runs of table 2; however, it could not be continued indefinitely in a generator

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[1] Numbers in parentheses refer to literature cited, page 5.

Table 1.- Effect of location of tuyère on composition of gas

(whole corncobs used as fuel)

Components in gas	Distance of tuyère below cover of hopper					
	19 1/2 inches	18 inches	16 1/2 inches	16 1/2 inches	15 inches	15 inches
	Composition					
H_2 percent	9.98	12.10	11.95	12.32	12.77	11.76
CO "	11.97	13.75	15.86	16.54	15.00	15.36
CH_4 "	3.74	3.25	3.45	3.50	2.68	4.09
CO_2 "	11.92	14.20	13.40	13.92	14.80	15.48
O_2 "	2.98	1.00	.68	.00	.00	.00
N_2 "	59.40	55.70	54.61	53.70	54.70	53.35
B.t.u./cu. ft.	103.3	110.1	117.9	121.6	110.1	122.3
B.t.u./lb.	3510.	3600.	3770.	4240.	3650.	4400.
Air flow(cu. ft. per min.)	2.91	2.82	2.87	3.34	2.89	3.40

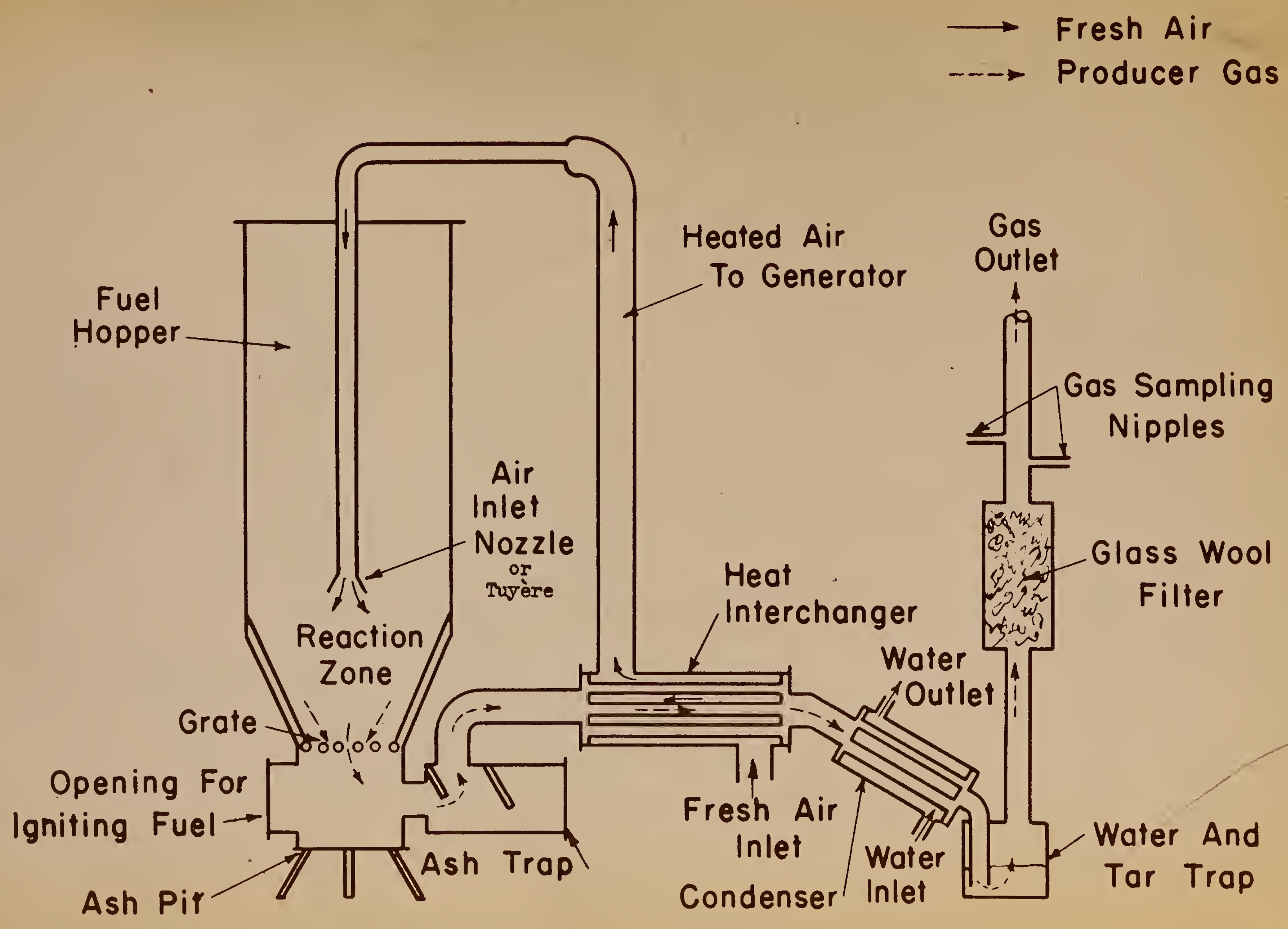

Figure 1. Experimental Gas Producer

Table 2.- Composition of gas when coarsely ground corncobs were used as fuel

Run	Components of gas						Com-bustible	Low heating value
	CO_2	O_2	H_2	CO	CH_4	N_2		
	%	%	%	%	%	%	%	B. t u./cu. ft.
No. 1	11.07	0.36	15.25	24.90	3.50	44.93	43.65	162
	9.51	.00	8.66	16.83	6.05	58.90	31.54	140
No. 2	9.00	.00	15.87	25.35	2.35	46.65	43.57	155
	11.98	.35	16.52	23.12	3.13	44.90	42.77	156
No. 3	10.40	.00	16.64	24.55	2.08	46.32	43.27	151
	10.49	.00	15.23	22.55	1.66	50.10	39.44	137
Average	10.54	.12	14.69	22.88	3.13	48.63	40.70	150

without stoker arrangement, since the residual charcoal finally became mixed with so much ash that ignition was impossible. It was necessary, therefore, to discard the residue after a time dictated by experience The differences in composition observed in the samples of gas from runs No 1 and No. 3 may be explained on the basis outlined above, since the charge was relatively small, and the time of running was therefore short. Because of the low density of the fuels used, it was necessary to rap the hopper frequently, somewhat imitating the jolting of a vehicle to prevent formation of blow holes.

No marked trend in gas composition with time, as has been observed elsewhere (4), was noted here. For comparison with commercially produced small generators of European origin, wood was used as fuel. Data shown in table 3 indicate no essential difference in performance.

Table 3.- Performance data of various generators

Type of generator	Components of gas							Low heat of combustion
	CO_2	C_nH_m	CO	H_2	CH_4	O_2	N_2	
	Percentage composition							B.t.u./cu.ft.
Imbert generator	11.8	0.2	23.4	16.4	2.4		45.8	155
Vehicle P 937(5)	16.0	.3	15.7	22.0	2.8		43.2	151
Imbert generator	15.7	.3	16.8	20.0	3.1		44.1	152
Vehicle BN (5)	13.9	.2	17.4	20.9	1.0		55.3	134
Kromag generator	14.1	.6	16.0	20.6	1.9		46.8	146
P 879 (5)	15.57	-	18.38	8.95	5.52	0.35	51.25	141
Experimental gas producer	10.35	-	24.38	14.67	3.51	.35	46.75	159

Incidental to this investigation, the heats of combustion of corncobs of a number of corn varieties grown in different soil and in different years were determined in a Parr adiabatic calorimeter. The results expressed in B.t.u./lb., oven-dry basis, ranged from 7874 to 8146 with an average of 8004.

Heat-balance calculations were made in two instances and are summarized in table 4.

Table 4.- Heat-balance calculations (whole corncobs used as fuel)

Heat input		Heat output		
	B.t.u./hr.		B.t.u./hr.	Percent
		Heat content of charcoal and residual tar................	9,630	14.46
		Heat content of moisture leaving the generator.......	2,200	3.30
		Heat content of gas above inlet temperature..........	780	1.17
		Heat content of combustible gas.........................	36,410	54.67
		Heat losses through radiation, condensation, etc.	17,580	26.40
Heat of combustion of corncobs.....	66,600	Total.............	66,600	

Efficiency $\frac{54.67}{100-14.46} = 64\%$

A similar calculation showed that ground corncobs gave practically identical efficiency.

The results given constitute only a small part of the data obtained; however, it is thought that their presentation will furnish a sufficiently clear overall picture of the possibilities.

Acknowledgement

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